

## PATENT COOPERATION TREATY

PCT

## INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY



(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

REC'D 08 FEB 2006

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Applicant's or agent's file reference TS 6368 PCT	<b>FOR FURTHER ACTION</b> See Form PCT/PEA/416	
International application No. PCT/EP2004/052826	International filing date (day/month/year) 05.11.2004	Priority date (day/month/year) 07.11.2003
International Patent Classification (IPC) or national classification and IPC E21B43/12, E21B17/01		
Applicant SHELL INTERN. RESEARCH MAATSCHAPPIJ B.V. et al.		
<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 5 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p>a. <input checked="" type="checkbox"/> sent to the applicant and to the International Bureau) a total of 6 sheets, as follows:</p> <p><input checked="" type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> <p>b. <input type="checkbox"/> (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p>		
<p>4. This report contains indications relating to the following items:</p> <p><input checked="" type="checkbox"/> Box No. I Basis of the opinion</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p>		
Date of submission of the demand  06.09.2005	Date of completion of this report  07.02.2006	
Name and mailing address of the international preliminary examining authority:   European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized Officer  Georgescu, M  Telephone No. +49 89 2399-7502  	

**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/EP2004/052826

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**Box No. I Basis of the report**

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1. With regard to the **language**, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.
- ☐ This report is based on translations from the original language into the following language , which is the language of a translation furnished for the purposes of:
- ☐ international search (under Rules 12.3 and 23.1(b))
  - ☐ publication of the international application (under Rule 12.4)
  - ☐ international preliminary examination (under Rules 55.2 and/or 55.3)
2. With regard to the **elements\*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

**Description, Pages**

1, 5-12	as originally filed
2-4	received on 05.09.2005 with letter of 05.09.2005

**Claims, Numbers**

1-16	received on 05.09.2005 with letter of 05.09.2005
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**Drawings, Sheets**

1/5-5/5	as originally filed
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- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing *(specify)*:
  - ☐ any table(s) related to sequence listing *(specify)*:
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
  - ☐ the claims, Nos.
  - ☐ the drawings, sheets/figs
  - ☐ the sequence listing *(specify)*:
  - ☐ any table(s) related to sequence listing *(specify)*:

\* If item 4 applies, some or all of these sheets may be marked "superseded."

**INTERNATIONAL PRELIMINARY REPORT  
ON PATENTABILITY**

International application No.  
PCT/EP2004/052826

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**Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

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1. Statement

Novelty (N)	Yes: Claims	1-16
	No: Claims	
Inventive step (IS)	Yes: Claims	1-16
	No: Claims	
Industrial applicability (IA)	Yes: Claims	1-16
	No: Claims	

2. Citations and explanations (Rule 70.7):

**see separate sheet**

Reference is made to the following documents:

D1: US 1 665 540

D2: US 4 544 207

D3: EP 0 288 106

**V - Reasoned statement with regard to novelty, inventive step or industrial applicability**

**V-1 Claims 1 and 10**

D1, which is considered as the closest prior art, describes a method for dispersing gas bubbles (column 1, line 15) in a production tubing (column 1, lines 2-4), the method comprising inserting at least one bubble breaker assembly (12, 13) in the tubing (fig.1), which assembly comprises a plurality of orifices that are located in a substantially eccentric position relative to a central axis (the majority of the pores of the material 12 and of the holes in plate 13 - lower one - are off the central axis) of the tubing.

The subject-matter of claim 1 is therefore new and the claim meets the novelty requirements of Art. 33(2)PCT.

The distinguishing feature of claim 1 with regard to D1 is the presence of the gas injection points along the length of the tubing upstream of the bubble breakers.

The technical problem to be solved can be seen as how to improve the lifting of the oil column.

D1 deals with the improvement of flow through an intake conduit of a pump which is placed on a specific position on the production tubing. As the other prior art documents do not deal with gas injection lifting, the skilled man would not find obvious to combine the two techniques without performing an inventive activity. Therefore, claim 1 meets the requirement for inventive step of Art. 33(3) PCT.

Similar arguments apply to claim 10.

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(SEPARATE SHEET)**

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V-2 Claims 2 to 9 and 11 to 16

Claims 2 to 9 and 11 to 16 as dependent claims from claim 1 respectively 16 also meet the requirements of Art. 33 PCT.

05. 09. 2005

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(76) more orifice containing turbulence promoters which may comprise plates containing orifices of various shapes.

The method and system according to the preamble of claims 1 and 10 are known from US patent 1665540.

5 This prior art reference discloses a bubble breaking and gas separation assembly for a well with an intake screen for reducing gas bubbles, a liquid trap, a liquid outlet which is connected to the production tubing and a gas outlet which is connected to the annulus surrounding the tubing.

10 It is an object of the present invention to provide a method and bubble breaker assembly, which further enhance the mixing of gaseous and liquid fractions in the conduit such that the size of the gas bubbles is further decreased and the gas bubbles are distributed as a finely dispersed froth in the multiphase fluid stream.

#### SUMMARY OF THE INVENTION

20 The method according to the invention for dispersing gas bubbles in a multiphase fluid transportation conduit comprises inserting at least one bubble breaker assembly in the tubing, which assembly comprises a plurality of orifices that are located in a substantially eccentric position relative to a central axis of the tubing, characterised in that lift gas is injected at one ore more downhole gas injection points spaced along the length of the production tubing to enhance oil production from the well, and that one or more bubble breaker assemblies with eccentric orifices are arranged at selected distances downstream of the lift gas injection points.

30 It has been found that the use of a bubble breaker assembly in which a plurality of eccentric orifices are arranged significantly enhances the dispersion of relatively large gas bubbles into a large amount of small

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gas bubbles, which are uniformly distributed in the multiphase fluid stream.

5 In an embodiment a flow restriction may comprise a disk-shaped plate in which at least two eccentric orifices are arranged, and which disk may be removably secured to the inner wall of the conduit, for example by a clamping assembly which can be contracted if the plate needs to be removed.

10 Preferably a plurality of flow restrictions are arranged at selected distances along the length of the conduit, wherein at least two of said flow restrictions comprise disk-shaped plates in which different patterns of eccentric orifices are arranged

15 In an embodiment at least one flow restriction may comprise a pair of eccentric orifices that are located substantially symmetrically relative to a plane of symmetry in which the central axis of the conduit lies.

20 Alternatively at least one flow restriction may comprise three or more equidistant eccentric orifices that are arranged at regular angular intervals relative to a longitudinal axis of the conduit.

25 In the fluid stream downstream of the gas-injection point(s) the gas bubbles will tend to coalesce into steadily growing larger gas bubbles, known as gas slugs or Taylor bubbles, and by arranging a series of bubble breakers according to the invention, each with eccentric orifices, an intensively mixed low density multiphase stream of crude oil and uniformly distributed small gas bubbles is created throughout the length of the production tubing.

30 The invention also relates to a system for dispersing gas bubbles in a multiphase fluid transportation conduit, which system comprises at least one bubble breaker assembly which is arranged within the tubing, which

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assembly comprises a plurality of orifices that are located in a substantially eccentric position relative to a central axis of the tubing characterised in that one or more downhole lift gas injection points are arranged  
5 along the length of the production tubing to enhance oil production from the well, and that one or more bubble breaker assemblies with eccentric orifices are arranged at selected distances downstream of the lift gas injection points.

10 Further features, advantages and embodiments of the method and system according to the present invention are detailed in the following detailed description of preferred embodiments and in the appended claims, abstract and drawings.

15 BRIEF DESCRIPTION OF THE DRAWINGS

Some preferred embodiment of the method and system according to the present invention will be described by way of example with reference to the accompanying drawings, in which:

20 Fig. 1 is a schematic three-dimensional view of a production tubing in a well into which lift gas is injected and which comprises downstream of the gas injection point a bubble breaker assembly with eccentric orifices according to the present invention which serve  
25 to break up coalesced large gas bubbles into a large amount of finely dispersed small gas bubbles;

Fig. 2 is a schematic three-dimensional view of a production tubing in a well in which an alternative embodiment of a bubble breaker with four eccentric  
30 orifices is arranged;

Fig. 3 is a longitudinal sectional view of a bubble breaker which is clamped between a pair of retrievable well tubulars;



C L A I M S

1. A method for dispersing gas bubbles in a production tubing (4) in an oil production well (1), the method comprising inserting at least one bubble breaker assembly (16) in the tubing (4), which assembly (16) comprises a plurality of orifices (18) that are located in a substantially eccentric position relative to a central axis of the tubing (4), characterised in that lift gas is injected at one or more downhole gas injection points (6) spaced along the length of the production tubing (4) to enhance oil production from the well (1), and that one or more bubble breaker assemblies (16) with eccentric orifices (18) are arranged at selected distances downstream of the lift gas injection points (6).

2. The method of claim 1, wherein at least one bubble breaker assembly (16) comprises a disk-shaped plate (17) in which at least two eccentric orifices (18) are arranged.

3. The method of claim 1 or 2, wherein a plurality of bubble breaker assemblies (16) are arranged at selected distances along the length of the tubing (4).

4. The method of claim 3, wherein the at least two of said bubble breaker assemblies (16) comprise disk-shaped plates (17) in which different patterns of eccentric orifices (18) are arranged.

5. The method of any preceding claim, wherein at least one bubble breaker assembly (16) comprises a pair of eccentric orifices (18) that are located substantially

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symmetrically relative to a plane of symmetry in which the central axis of the tubing (4) lies.

6. The method of claim 1, wherein at least one bubble breaker assembly (16) comprises at least three eccentric orifices (18).

7. The method of claim 1, wherein the lift gas is injected through at least one lift gas injection orifice (6) in which a porous membrane is arranged such that finely dispersed gas bubbles are injected into the production tubing (4).

8. A method of producing crude oil, wherein large gas slugs, that are known as are Taylor bubbles (15), are broken up into finely dispersed smaller gas bubbles by means of one or more bubble breaker assemblies (16) with eccentric orifices (18) in accordance with the method according to claim 1.

9. The method of claim 8, wherein the ratio between the injected flux of lift gas ( $Q_g$ ) and the flux of crude oil ( $Q_l$ ) is less than 400 standard cubic meters per cubic meter.

10. A system for dispersing gas bubbles in a production tubing (4) in an oil production well (1), the system comprising at least one bubble breaker assembly (16) which is arranged within the tubing (4), which assembly (16) comprises a plurality of orifices (18) that are located in a substantially eccentric position relative to a central axis of the tubing (4) characterised in that one or more downhole lift gas injection points (6) are arranged along the length of the production tubing (4) to enhance oil production from the well (1), and that one or more bubble breaker assemblies (16) with eccentric orifices (18) are arranged at

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selected distances downstream of the lift gas injection points (6).

5 11. The system of claim 10, wherein at least one bubble breaker assembly (16) comprises a disk-shaped plate (17) in which at least two eccentric orifices (18) are arranged.

12. The system of claim 10 or 11, wherein a plurality of bubble breaker assemblies (16) are arranged at selected distances along the length of the tubing (4).

10 13. The system of claim 12, wherein the at least two of said bubble breaker assemblies comprise disk-shaped plates (17) in which different patterns of eccentric orifices (18) are arranged.

15 14. The system of any one of claims 10-13, wherein at least one bubble breaker assembly (16) comprises a pair of eccentric orifices (18) that are located substantially symmetrically relative to a plane of symmetry in which the central axis of the tubing (4) lies.

20 15. The system of claim 10, wherein at least one bubble breaker assembly (16) comprises at least three substantially equidistant eccentric orifices (18).

25 16. The system of claim 15, wherein the accumulated cross-sectional area of the openings of orifices (18) is less than fifty per cent of the cross-sectional area of the tubing (4).

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